Exit Presentation

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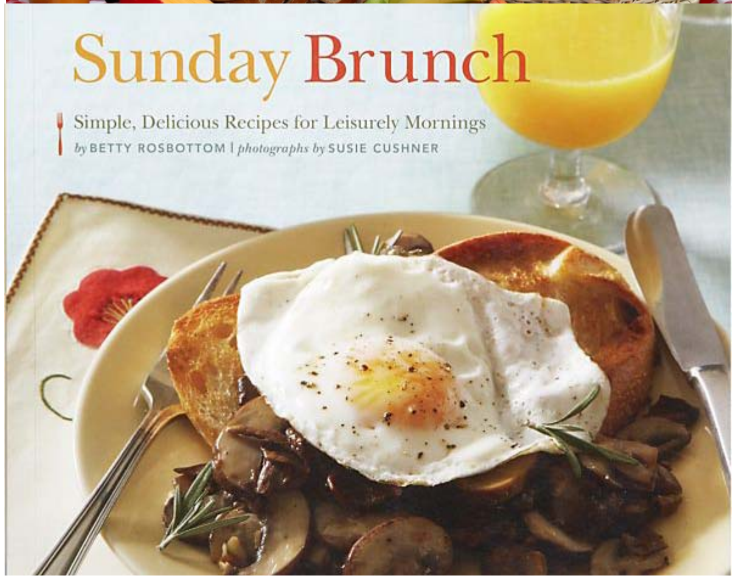
Neuroscience

Space Life Sciences
Summer Institute

Introduction

- B.Eng Aerospace 2010
- M.S. Space Life Sciences 2012 (dnf)
- PhD. Kinesiology/Space Life Sciences (ongoing)
    - Gravitational neurophysiology
    - Artificial gravity
    - Space flight countermeasures
    - Motor control
    - Fall risk



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http://homefoodsafety.org/vault/2499/web/Picnic_Eating.jpg
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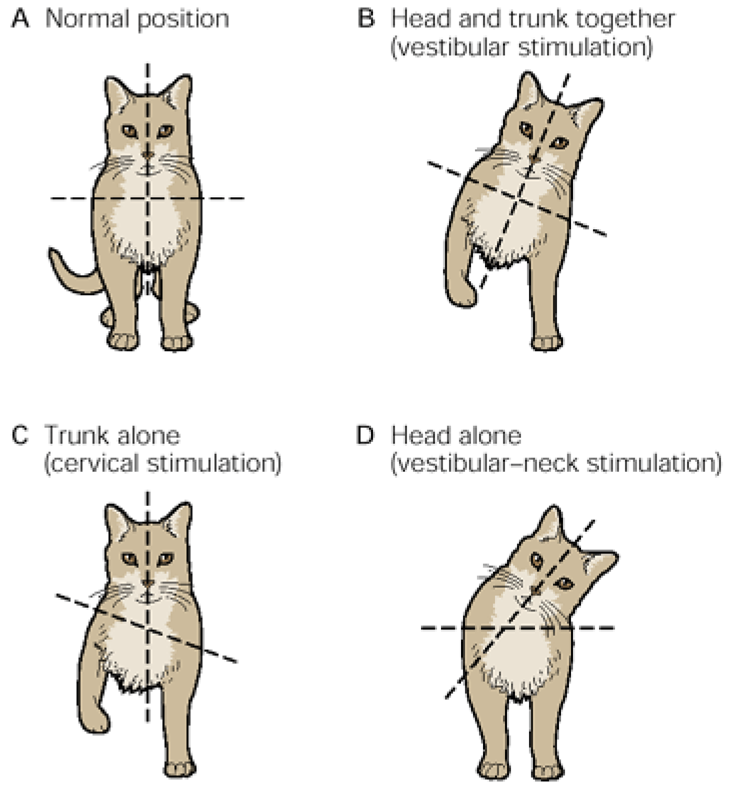
Objectives of Internship

Project 1:
Head-trunk coordination



Project 2:
Visual flow

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http://danbaileyphoto.com/blog/wp-content/uploads/2012/11/Visual-Flow.jpg
Principles of Neuroscience: http://bit.ly/1nWmXwc

Understanding the effects of spaceflight on head-trunk coordination during walking and obstacle avoidance

VISUAL SYSTEM

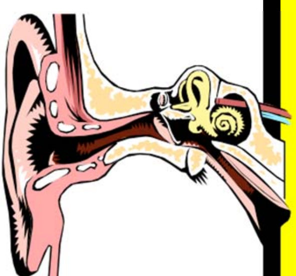
VESTIBULAR SYSTEM

ANGULAR ACCELERATION

(Semicircular Canals)

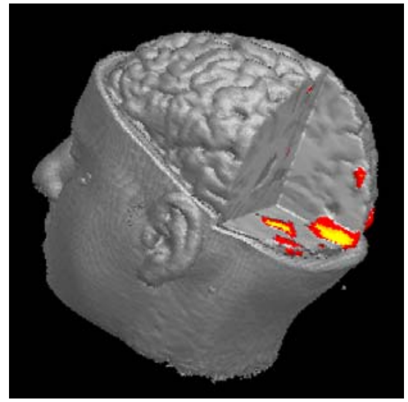
LINEAR ACCELERATION AND GRAVITY

(Otoliths)



PROPRIOCEPTIVE SYSTEM

TACTILE SYSTEM



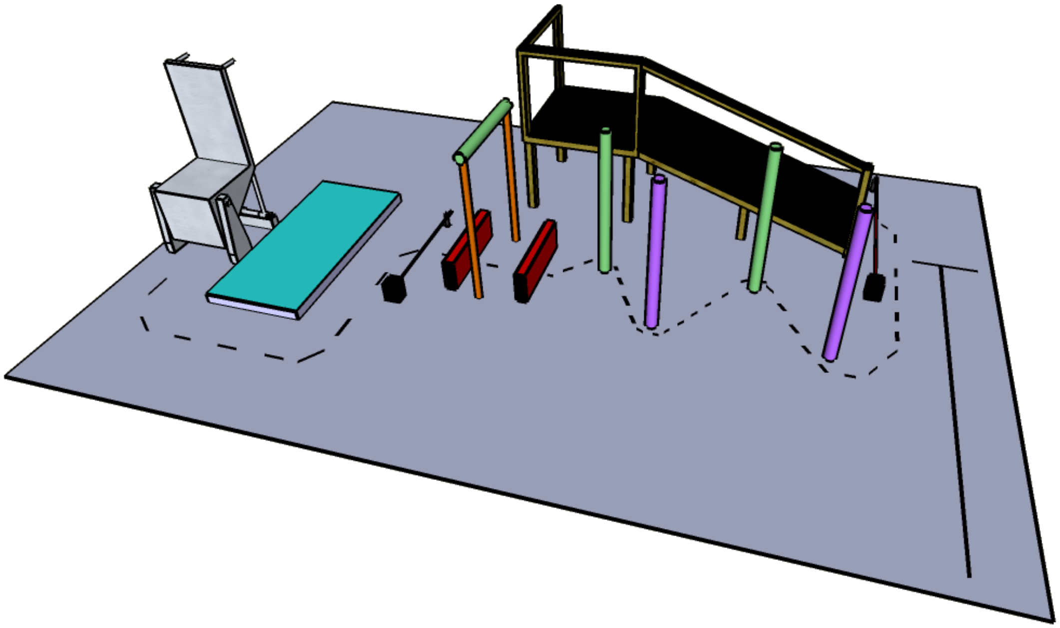
CENTRAL REINTERPRETATION OF SENSORY INPUT

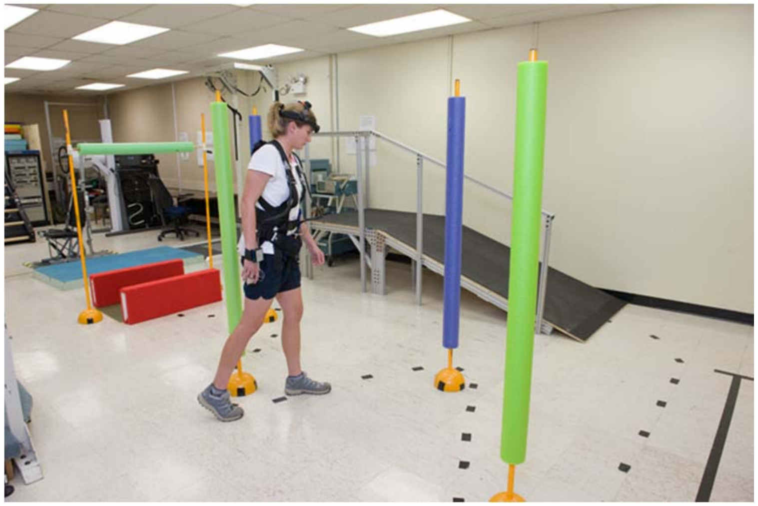
Control of movement in 0-g

Control of movement in 1-g

How do changes in these sensorimotor systems impact astronaut functional performance?

Seat Egress and Walk Test





Subject unbuckled a harness, stood up from a seat and then completed an obstacle course.

<u>Testing occurred with</u>:

- Seat upright (Upright Seat Egress)
- Seat positioned with its back to the floor (Supine Seat Egress)

Testing Schedule

Preflight

L-180 L-60 L-30

6 months in space

Postflight

R+1 R+6 R+30

Pre-bed rest

BR-12 BR-7 BR-1

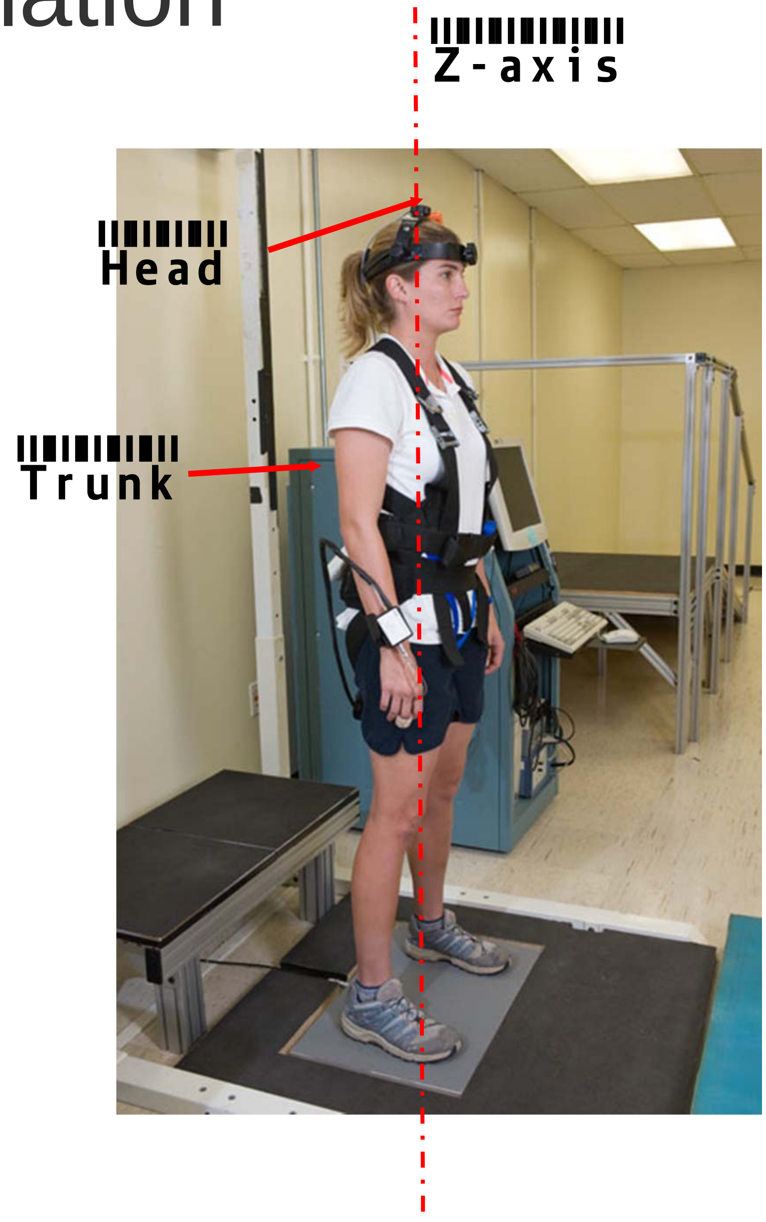
70 days in bed rest

Post-bed rest

BR+0 BR+1 BR+6 BR+12

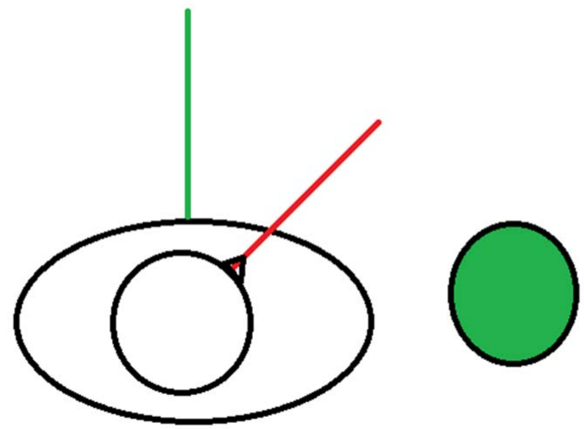
Measurements and population

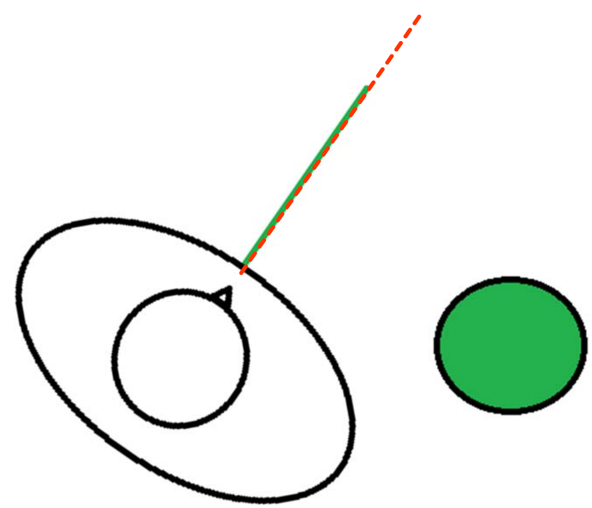
- Kinematic measures (Xsens 6DOF IMU)
- Yaw rotation about Z axis
- 26 bed rest participants
  - 10 BR Controls
  - 16 BR Exercisers
- 13 6-month ISS participants
- Comparison between
  - BR-1 and BR+0
  - L-30 and R+1



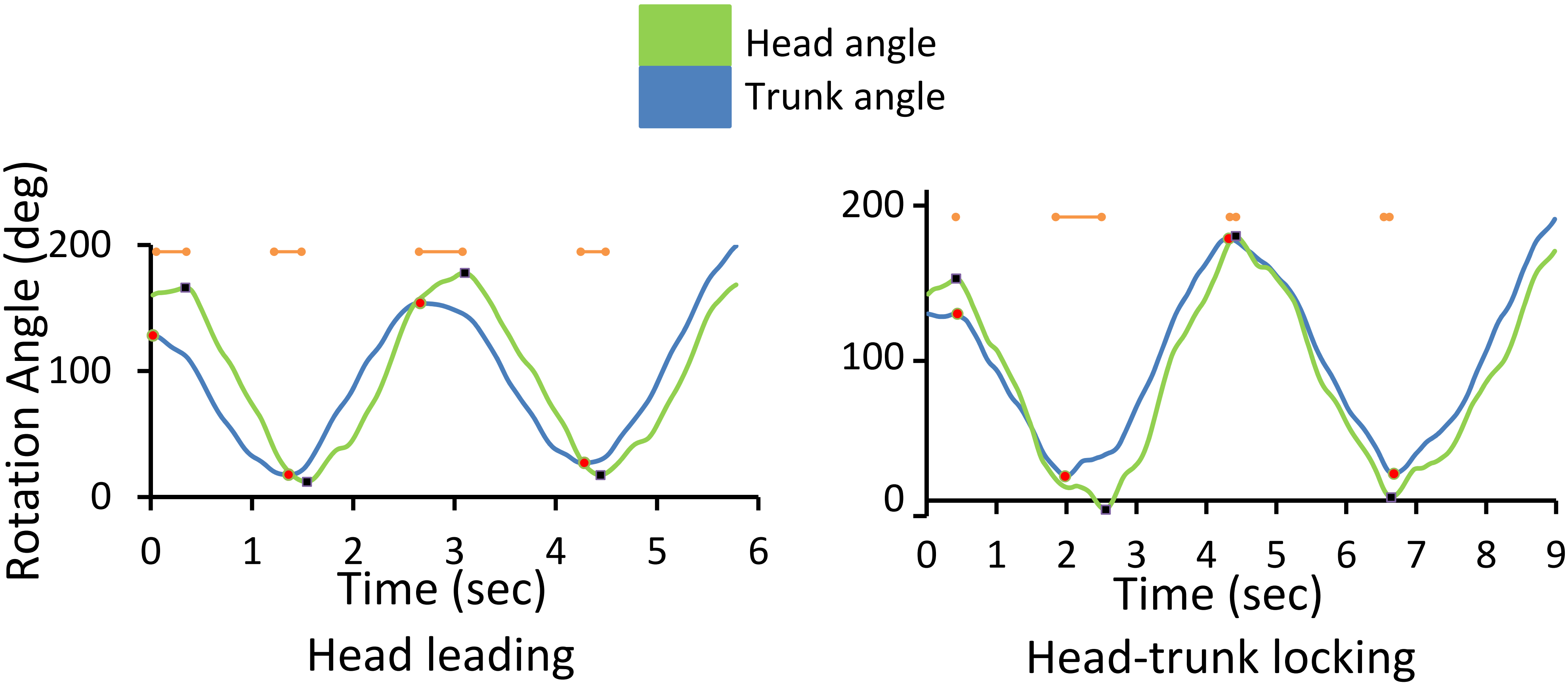
Movement Strategies
Head and Trunk Coordination

- Decreased latency (locking) related to vestibular pathology
  - BVL
  - Head-pitch locking post-flight
- Trajectory planning
  - Head leading
  - ‘En Bloc’
- Hypothesis
  - Neuro-vestibular adaptation will exhibit head-to-trunk locking during turning, exhibited by a decrease in the latency between head and trunk movements
- Latency
  - Time difference between head and trunk movement





Data analysis



Pre-Flight (L-30)

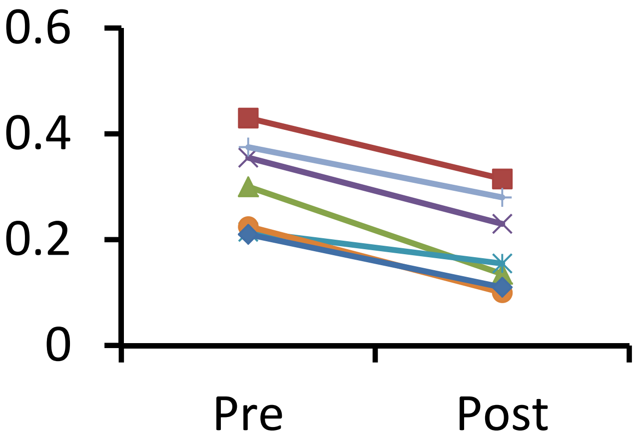
Post-Flight (R+1)

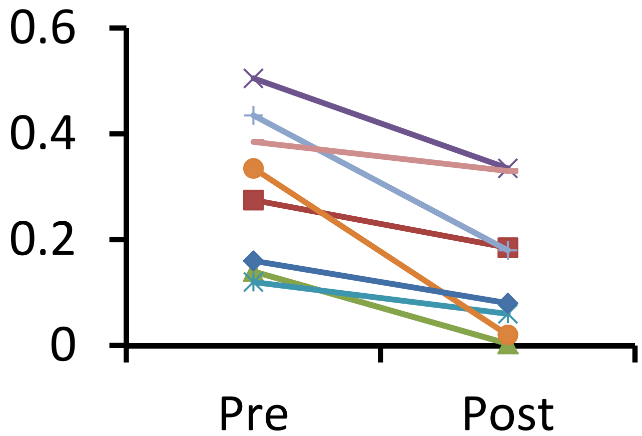
Head-Trunk Locking

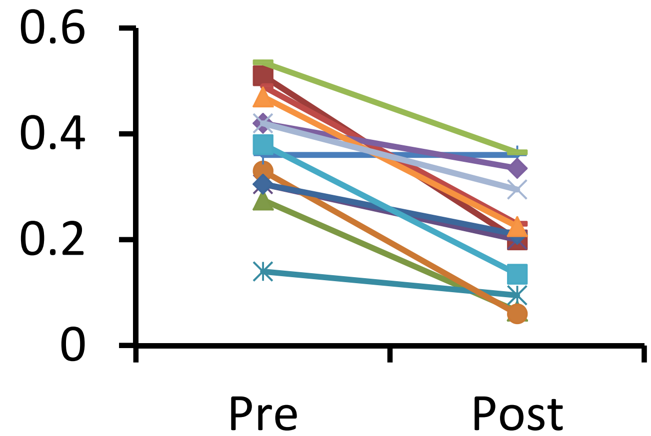
ISS

Bed Rest Control

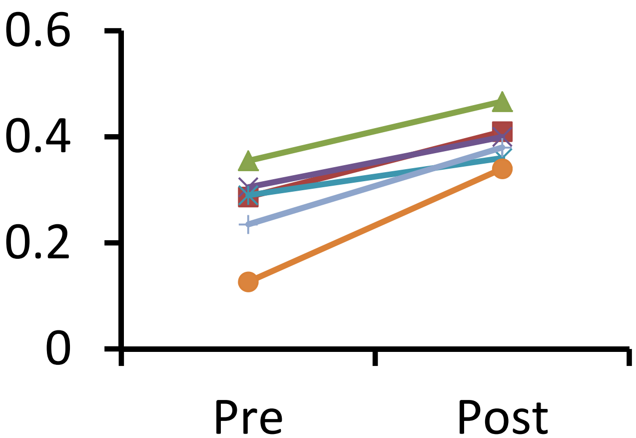
Bed Rest Exercise

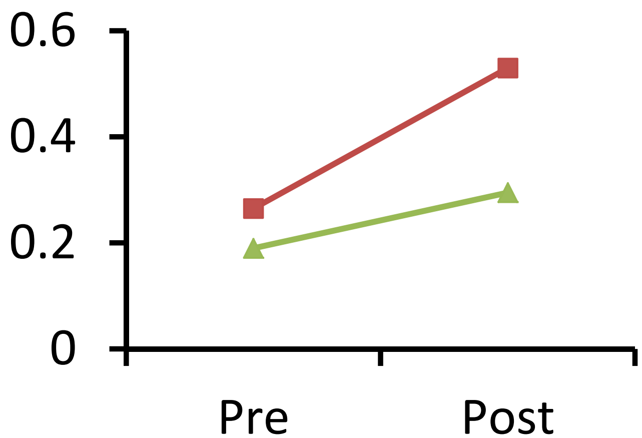


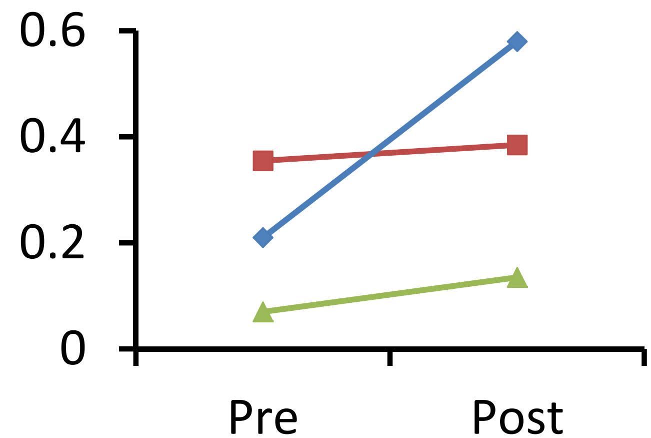




Head-Trunk Leading





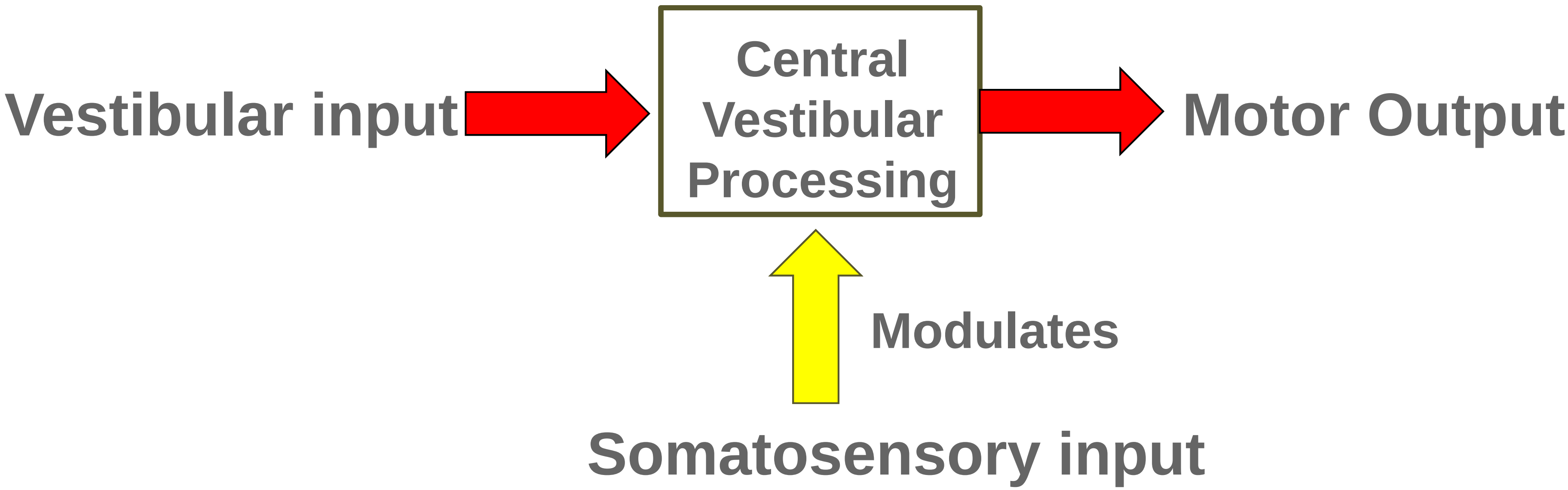


Observations and conclusions

Mission	Responders	Non-responders
ISS	7	6
Bed Rest – Control	8	2
Bed Rest – Exercise	13	3

- Divided response in ISS participants
  - Rate and strategy of adaptation – sensorimotor integration
- Head-trunk coordination changes after bed rest
  - Unexpected response – convergence theory
- No obvious difference between bed rest control and exercise population in this measure (80% vs. 87% responders)

Somatosensory input modulates central vestibular processing

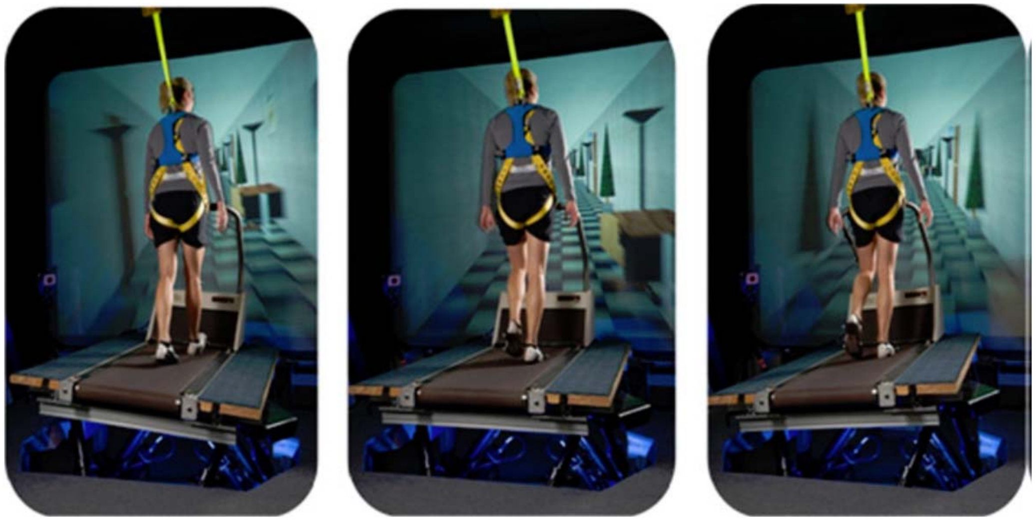


- Convergence of somatosensory inputs from the limbs onto vestibular nucleus neurons. (*Jian et al, Exp Brain Res* 2002).
- Subjects with diabetic peripheral neuropathy showed increased sensitivity to galvanic vestibular stimulation, leading to impaired postural capability. *(Horak and Hlavacka J Neurophys 2001)*.
- Unloaded treadmill locomotion produces adaptive changes in vestibularly mediated head movement control. (*Mulavara et al JVR 2012).*

Development and testing of a visual flow perturbation system using virtual reality and head mounted displays

Visual flow as an adaptation paradigm

- Training countermeasure
- Batson et al. 2011
  - Stride frequency
  - Reaction time
  - Anxiety
- Brady et al. 2012
  - Adaptation to changes in visual flow
  - Differences among individuals –
    Fast v. slow adaptors



Learning to learn through adaptation

- Microgravity adaptation
  - Space motion sickness (to µg)
  - Balance and postural instability (from µg)
- Adaptive generalizability as microgravity countermeasure
  - Ability to adapt to a novel environment transfers to other environments
- Is it possible to train and improve one's adaptive generalizability?
  - Less susceptible to changes in environment

Individualized training for adaptability

- Current system requires large, intrusive hardware
- Novel training paradigms
  - Inflight treadmill training
  - Balance training during bed rest
    - ‘Gravity bed’
- Goal: Solve technical problems to develop training protocols
  - Size and weight of present technology

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Oddsson et al. A rehabilitation tool for functional balance using altered gravity and virtual reality. Journal of NeuroEngineering and Rehabilitation 4:25, 2007

http://upload.wikimedia.org/wikipedia/commons/a/ae/TVIS_treadmill.jpg

Developing a virtual reality environment

- Oculus Rift
  - Development Kit 2
  - COTS hardware
  - Improved position tracking
- WorldViz Vizard
  - Development environment for virtual reality
  - Direct integration with Oculus SDK
- SketchUp
  - Building 3D environments

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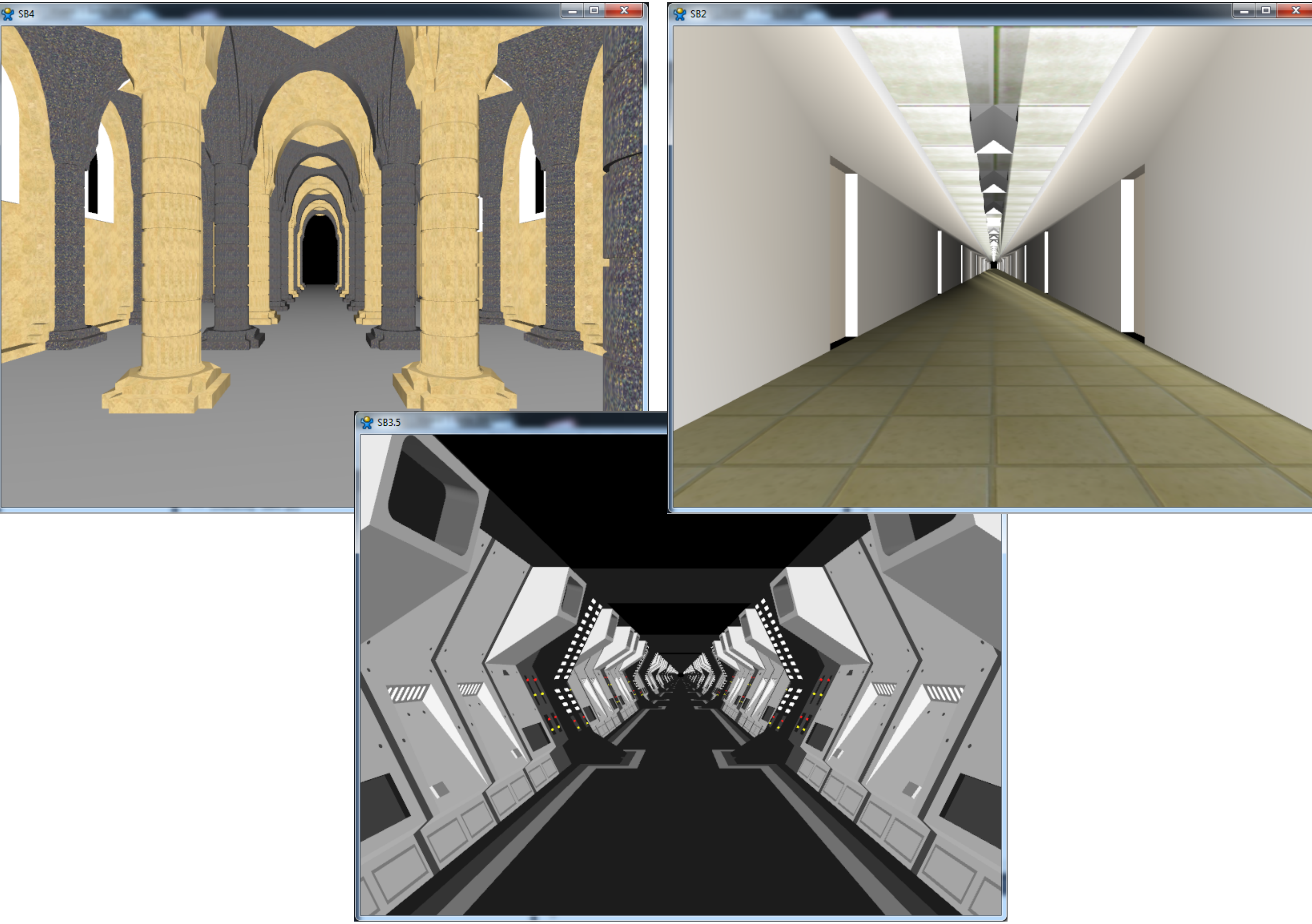
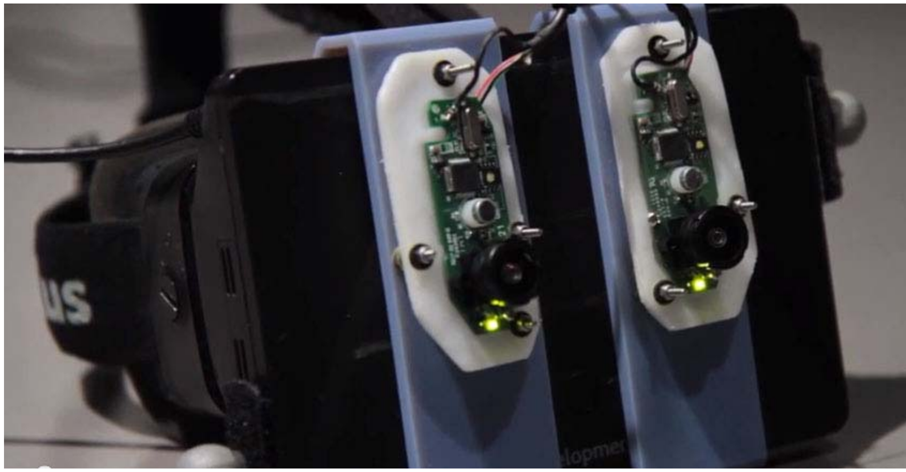
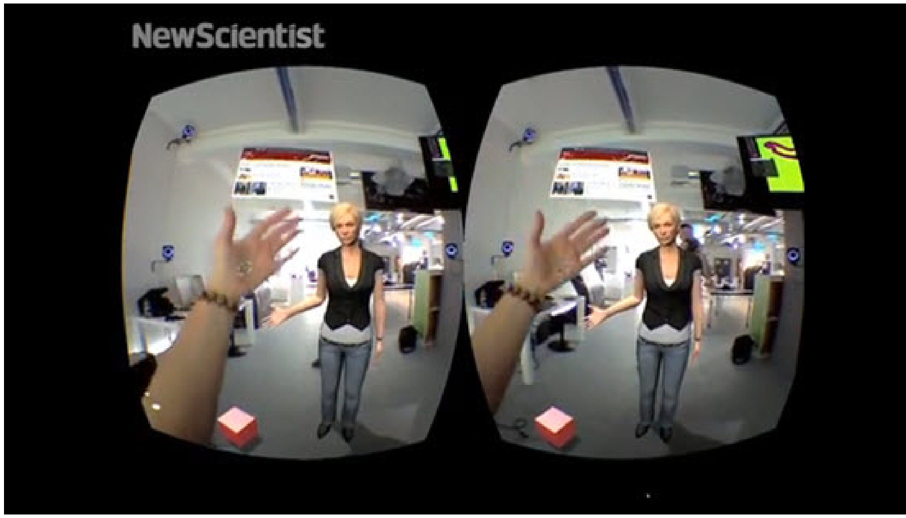
http://core0.staticworld.net/images/article/2014/02/oculus-rift-crystal-cove-100245805-orig.jpg
http://s3.amazonaws.com/static.oculusvr.com/website/2014/03/camera_dk2.jpg


SB4
SB2
SB3.5

Next steps

- Integrate WorldViz software with incoming hardware
- Complete pilot study IRB
- Compare pilot data with previous studies
- Investigate augmented reality
  - Visual flow in everyday life
  - Spaceflight countermeasure
  - Clinical populations





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http://www.telepresenceoptions.com/images/oculus_merged_reality_view.jpg
http://www.entertherift.fr/images/221-ar-rift-les-cameras.jpg

Acknowledgements

- Neurosciences Laboratory

  Jacob Bloomberg

  Chris Miller

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